Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

A 56.9
R31
ARS-41-123

7732

DEEP-TILLAGE INVESTIGATIONS ON ALLUVIAL SOIL IN THE SUGARCANE AREA OF LOUISIANA

LIBRARY
RECEIVED
JAN 8 1968
U. S. DEPARTMENT OF AGRICULTURE
BELTSVILLE BRANCH

October 1966 ARS 41-123
Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

CONTENTS

Page

Sugarcane area of Louisiana. 3
  Geographical sections 3
  Rainfall 5
Experimental procedures. 5
  Deep-tillage treatments. 8
  Measurements for evaluation of treatment 10
Results and interpretations 10
  Changes in soil physical properties 10
  Soil moisture response 13
  Crop response 18
  Variety x tillage interpretations 20
Summary and conclusions 21

Prepared in

Soil and Water Conservation Research Division
and
Crops Research Division
Agricultural Research Service
United States Department of Agriculture

in cooperation with
Louisiana Agricultural Experiment Station

DEEP-TILLAGE INVESTIGATIONS ON ALLUVIAL SOIL IN THE SUGARCANE AREA OF LOUISIANA

By Irwin L. Saveson, Zane F. Lund, and Lester G. Davidson[1]

In Louisiana approximately 350,000 acres of sugarcane are grown with about 48 percent of the total acreage in the lower Mississippi River section, and 26, 21, and 5 percent, respectively, in the Gulf, Western, and Red River sections.

At the request of the Louisiana sugar planters, deep-tillage research was initiated in 1954. Their interest was stimulated by the benefits obtained with deep tillage in the Mississippi Valley cotton area of northern Louisiana where soil compaction problems limit water intake, storage, and root development.[2]

The research was to determine the extent of the compaction problems in the sugarcane area of Louisiana and the extent to which sugarcane land would respond to deep tillage. Evaluation of the deep-tillage treatment, soil physical properties, soil moisture response, and crop response cover crop years 1955 to 1962, inclusive.

SUGARCANE AREA OF LOUISIANA

The main portion of the sugarcane area of Louisiana is located in the southern Mississippi Valley alluvial plain, composed of Mississippi River bottomlands and silty uplands. Some sugarcane is also grown in the Red River bottomlands.

Geographical Sections

The sugarcane area of Louisiana can be divided geographically into four sections--the Mississippi River, the Gulf, the Western, and the Red River (fig. 1).

The Mississippi River section.--This section (experimental sites LA-8, LA-9, LA-14, LA-15, and LA-19) is typical southern Mississippi Valley Alluvium (delta plains). Before a stable Mississippi River levee system was established, major streams meandered over the area. Low meander belt ridges and natural levees of silty and sandy segments from channel deposits of rivers and their tributaries and crevasses are still in evidence. In general, soil textures are graded, with the coarser textures at the streambanks and the finer textures away from them. This general pattern of deposition is somewhat altered by flooding of crevasses, which scours out sloughs and redistributes the sediments. The sloughs become refilled with sediments by later floods. This pattern of deposition prevents a uniform texture throughout the soil profile.

The Gulf section.--This section (experimental sites LA-10 and LA-16) has the same general characteristics as the River section except for lower elevation. Because the elevation of some fields is too low for adequate drainage by gravity, the outlet ditches may require pumping.

---

[1] Agricultural engineer and soil scientist, Soil and Water Conservation Research Division, Baton Rouge, La., and research agronomist, Crops Research Division, Houma, La., respectively.

[2] Saveson, I. L., Lund, Z. F., and Sloane, L. W. Deep-tillage investigations on compacted soil in the cotton area of Louisiana. U.S. Agr. Res. Serv., ARS 41-41, 24 pp. 1961.

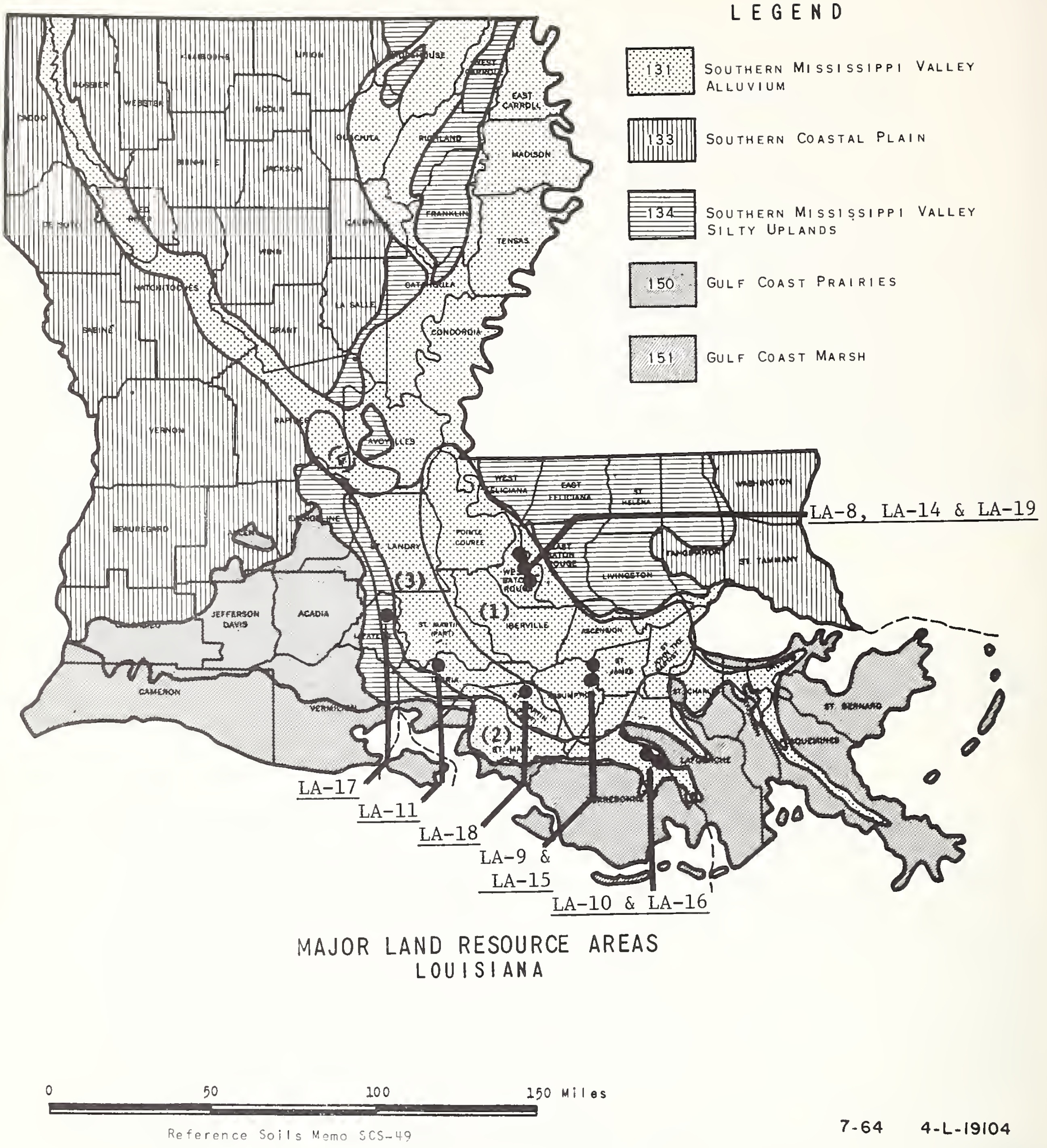
LEGEND
131 Southern Mississippi Valley Alluvium
133 Southern Coastal Plain
134 Southern Mississippi Valley Silty Uplands
150 Gulf Coast Prairies
151 Gulf Coast Marsh
LA-8, LA-14 & LA-19
LA-17
LA-11
LA-18
LA-9 & LA-15
LA-10 & LA-16
(1)
(2)
(3)
(4)
MAJOR LAND RESOURCE AREAS
LOUISIANA
0
50
100
150 Miles
Reference Soils Memo SCS-49
7-64 4-L-19104

Figure 1.--Geographical sections of the sugarcane areas of Louisiana: (1) Mississippi River, (2) Gulf, (3) Western, and (4) Red River.

The Western section.--This section (experimental sites LA-11, LA-17, and LA-18) includes the alluvial bottom and silty uplands along the Bayou Teche. The bottomlands have characteristics similar to those of the southern Mississippi Valley alluvium, whereas the silty uplands are predominantly loess soils.

The Red River section.--This section (no tests made) is considerably smaller than the other three sections and is composed primarily of the alluvial bottomlands.

Rainfall

Distribution of rainfall is more important for sugarcane production than the annual total of approximately 60 inches. In Louisiana the cultivation period for sugarcane is March through May. The crop is usually laid by late in May. Most planters prefer a dry May for weed control before the crop is laid by. During the growing period from May until late September, adequate, well-distributed rainfall is essential. A dry period during October, November, and December aids in ripening the cane, which in turn increases the sugar content and facilitates the harvest.

Figure 2 shows the departure from normal for the years of this investigation by geographic sections. The rainfall varied with individual tests, because of geographic location and summer showers.

The years 1955, 1956, 1960, and 1962 had below-normal rainfall, with the severest shortage in 1956 in the River section. The distribution was good in 1955, with ample rainfall during July and August. The years 1957, 1959, and 1961 had above-normal rainfall, with the Gulf section having the highest. The year 1958 had near-normal rainfall, with a small shortage in the Western section.

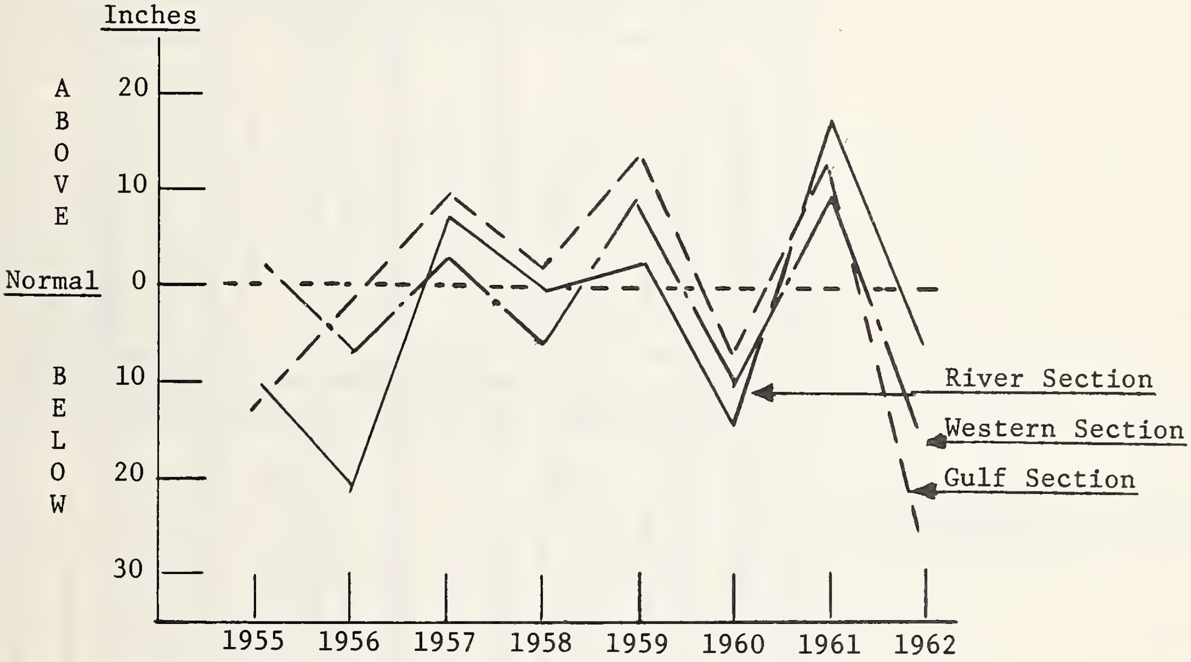

Figure 2.--Departure in rainfall from normal for different years and geographical sections.

EXPERIMENTAL PROCEDURES

The experimental sites were set up in the Mississippi River, the Gulf, and the Western sections. No tests were made in the Red River section. Most test sites, composed of about 50 acres, were classified on the basis of the major soil type in the test area. In most instances, small belts of related soil types were found within the test areas, which were grouped into the following soil categories for analysis and comparison of treatments:

1. Fine sandy loam alluvium, with some silt loam.
2. Silt loam alluvium.
3. Silty clay loam alluvium.
4. Clay alluvium.
5. Loess silt loam uplands.

The Soil Conservation Service surveyed, identified, and mapped the soils in each individual test site. Table 1 lists the sites, grouped by soil type, number of replications, tillage treatments, years worked, and crop years harvested.

The sugarcane fields were divided into cuts approximately 1,000 feet long and 120 feet wide; each cut was bounded by a headland on each end and a lateral ditch on each side. All rows ran parallel to the lateral ditches. The water between the rows was drained by 3 or 4 quarter drains across the rows to the lateral ditches. Each cut was used as a plot, because any division of the cut would introduce a drainage factor into the test and also complicate the harvesting of the crop for yield data.

The experiments were randomized block designs with either 2 or 4 replications (table 1). Figure 3 shows a typical experimental layout used for the tests.

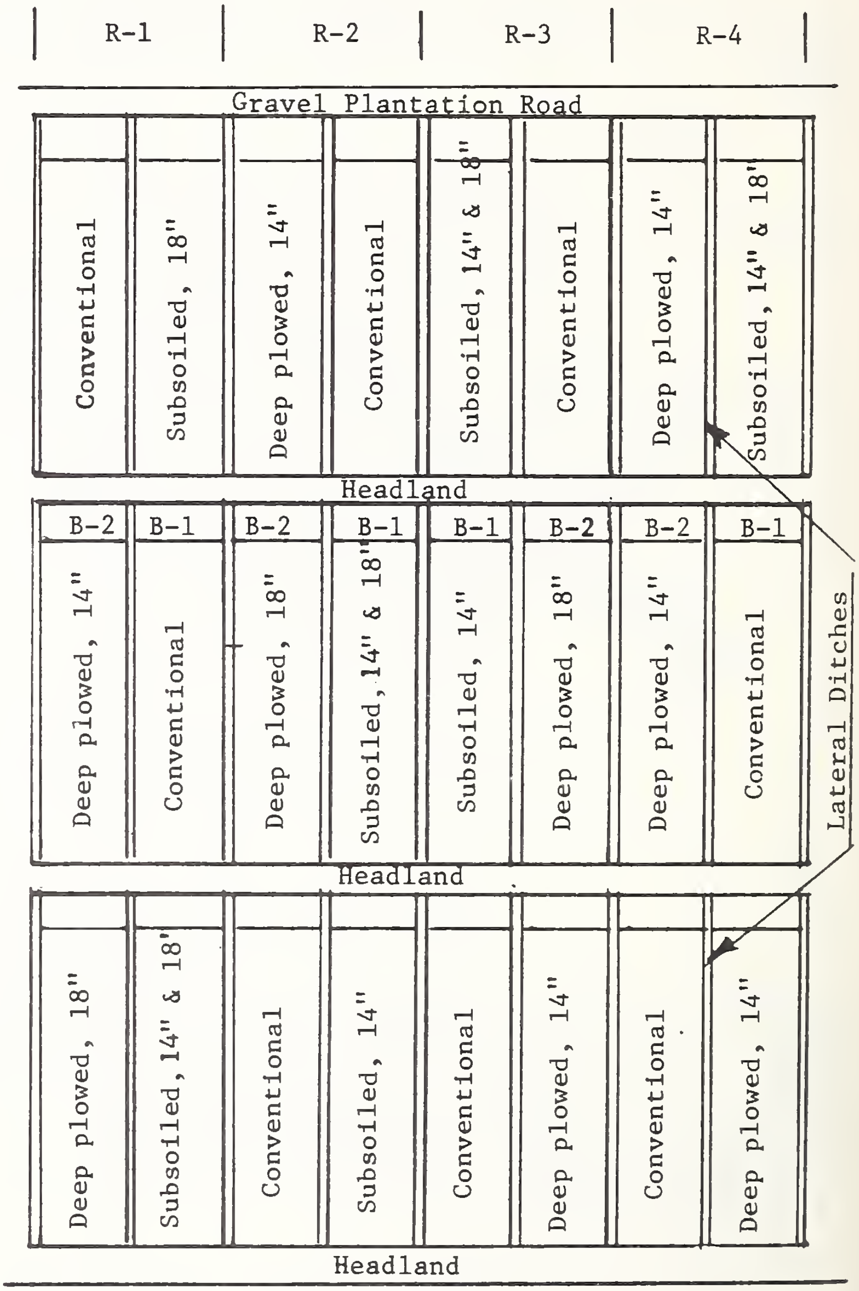

Figure 3.--A typical experimental layout for the deep-tillage study.

Table 1.--Information on kinds and dates of tillage treatments and types of sugarcane plantings that were harvested in experimental sites grouped into similar soil textural classes

Experimental sites			No. of replications	Tillage treatments						Year		Year crop harvested		
No.	Plantation	Section		Conventional	Subsoiled		Deep-plowed		Scarified	Worked	Reworked	Plant cane	1st ratoon	2d ratoon
				8 in.	18 in.	14 and 18 in.	14 in.	18 in.	14 in.					
FINE SANDY LOAM (COMMERCE AND MHOON) ALLUVIUM														
LA-8	Cinclare	River	2	X	--	X	X	X	X	1954	--	1955	1956	--
			2	X	--	X	X	X	--	--	1957	1958	--	--
LA-14	Additions	do	4	X	--	X	X	X	--	1956	--	1957	1958	--
LA-15	Madewood	do	4	X	--	X	X	X	--	1956	--	1957	1958	--
SILT LOAM (MHOON) ALLUVIUM														
LA-16	Georgia	Gulf	4	X	X	X	X	X	--	1956	--	1957	1958	1959
			4	X	--	X	X	X	X	--	1960	1961	1962	--
LA-19	Popular Grove	River	4	X	X	X	X	X	--	1956	--	--	1958	1959
SILTY CLAY LOAM (BALDWIN, MHOON, AND SHARKEY) ALLUVIUM														
LA-8	Cinclare	River	2	X	--	X	--	X	X	1954	--	1955	1956	--
			2	X	--	X	X	X	--	--	1957	1958	--	--
LA-10	Upper 10	Gulf	2	X	--	X	--	X	X	1954	--	1955	1956	--
LA-18	Oaklawn	Western	4	X	X	X	X	X	--	1956	--	1957	--	1959
CLAY (IBERIA AND SHARKEY) ALLUVIUM														
LA-9	Glenwood	River	2	X	--	X	--	X	X	1954	--	1955	1956	--
LA-11	Duhe	Western	4	X	--	X	--	X	X	1954	--	1955	1956	--
LOESS SILT LOAM (LINTONIA, OLIVIER, AND RICHLAND) UPLANDS														
LA-17	Billeaud	Western	4	X	X	X	X	X	--	1956	--	1957	1958	--

The sugarcane, a perennial crop, was harvested each year after planting for a period of 3 years. Before planting, the fields were in fallow from early spring until September to control johnsongrass. In this investigation, sugarcane was planted in September on rows 14 to 18 inches high and 6 feet apart, which is in accordance with practices in Louisiana. The first crop was harvested in November of the following year.

Deep-Tillage Treatments

Deep-tillage treatments were carried out during the summer to obtain maximum shattering, when the fields were driest and in fallow. These treatments were compared with the prevalent conventional tillage. The conventional method consisted of fallowing from January to September every fourth year. The fields were plowed 8 inches deep with a moldboard or disk plow, then disked, and bedded into rows. To further pulverize the soil, the rows were reversed by splitting with a special row plow, with halves of two adjacent rows forming one row. Heavy disk cultivators were used for additional row preparation.

The following five methods of deep tillage were used in this experiment:

1. Subsoiling 18 inches deep.--This modified method of subsoiling lifts and cracks the soil to a depth of 18 inches with 24-inch subsurface sweeps mounted on subsoiling shanks. Three sweeps are set on 40-inch centers. They give a 2-1/2-inch lift as they move through the soil (fig. 4).

2. Subsoiling 14 and 18 inches deep.--This modified method of subsoiling shatters the soil with subsurface sweeps operated simultaneously at 14 and 18 inches deep. Two additional sweeps are mounted ahead and between the sweeps used in subsoiling one level and are 4 inches above the rear sweeps (fig. 5).

3 and 4. Deep plowing, 14 or 18 inches.--This method consists of plowing either 14 or 18 inches deep with a four-bottom, 16-inch moldboard plow. The furrow slice is turned approximately 90 degrees and set on edge to place the soil layers in an almost vertical position (fig. 6). The original plans called for deep plowing 12 or 18 inches; however, a compacted layer in the 9- to 14-inch zone was encountered in all areas except in the clay soils. Since the plow would not operate at 12 inches, the depth was changed to 14 inches, which was below the compacted layer. This enabled the furrow slice to be turned on edge.

5. Scarifying, 14 inches deep.--The soil is mixed by scarifying to a depth of 14 inches with a heavy field cultivator equipped with closely spaced chisels (fig. 7). In some of the first tests this treatment overpulverized the surface, which retarded the infiltration of rainwater. For this reason, the first tests were discontinued. The same problem was encountered in the Louisiana cotton area with this method.[3]

---

[3] See footnote 2.

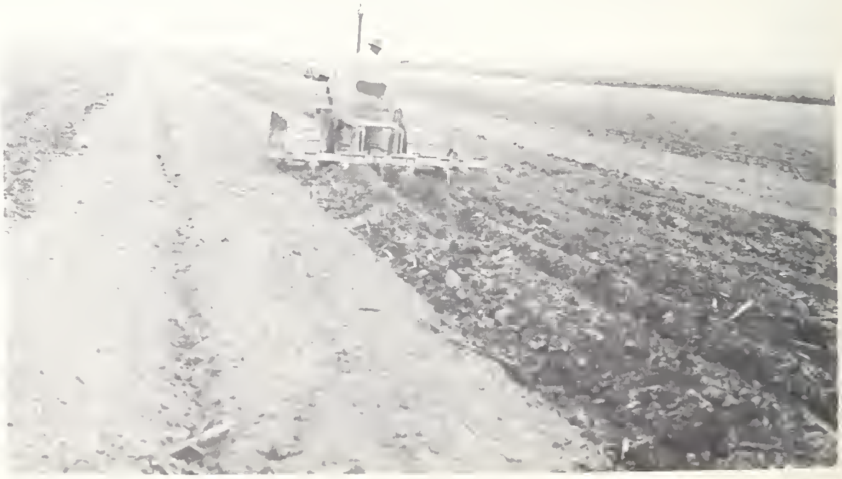

Figure 4.--Subsoiling 18 inches deep.

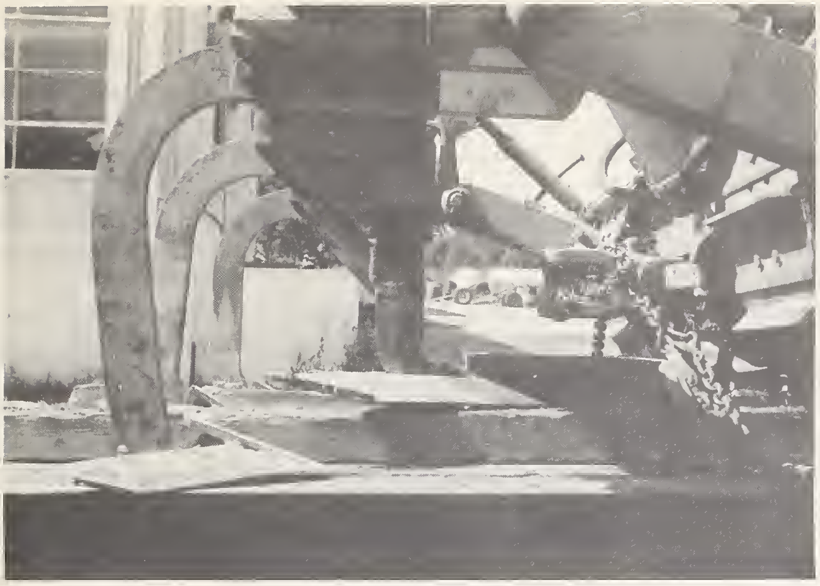

Figure 5.--Equipment for subsoiling at 14 and 18 inches deep.

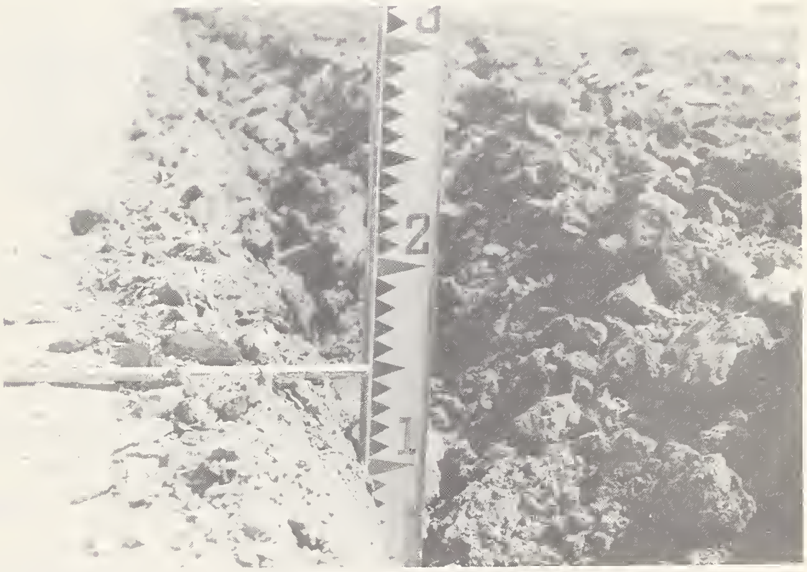

Figure 6.--Deep plowing 14 or 18 inches deep.

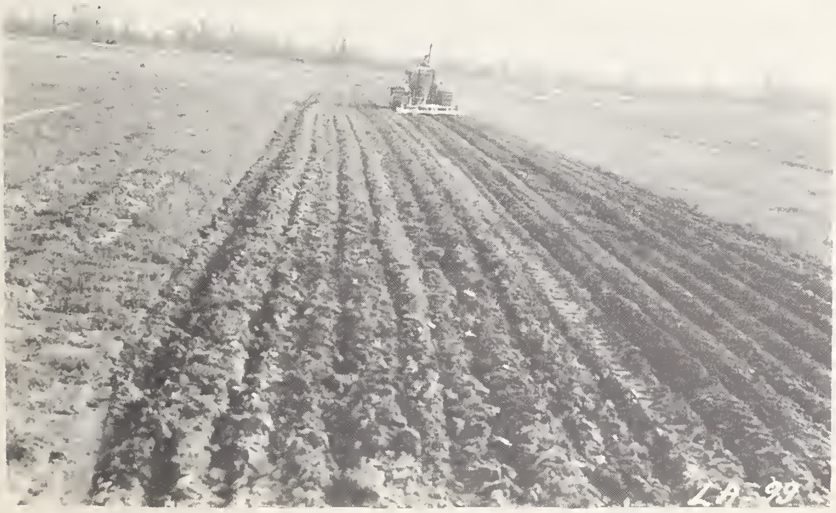

Figure 7.--Scarifying 14 inches deep.

Measurements for Evaluation of Treatment

Measurements of soil physical properties included permeability, bulk density, total pores, large pores, and particle size. In 1956, 3-inch cores were collected at 0- to 3-, 6- to 9-, and 12- to 15-inch depths with a Uhland-type sampler. These soil samples were taken immediately before the tillage treatments were imposed on LA-14 and LA-19 and again approximately 1 year later. On other tests they were sampled approximately 1 year after working and compared with conventional non-tilled plots. Data on the 6- to 9-inch depths and the 12- to 15-inch depths are given in tables 2 and 3, respectively.

The cores were brought into the laboratory, trimmed, allowed to saturate overnight, and placed on a permeability rack designed to give a hydraulic gradient of 2. Water was allowed to percolate through the sample for 24 hours, and then the percolate caught over a 1-hour period to measure the permeability rate. The cores were subjected to a tension of 60 cm. for 48 hours, and the loss in weight was used to calculate the percentage of large pores. The cores were placed in a forced-draft oven at 105^{0} C. for 48 hours. The net dry weight was used to calculate bulk density. Total porosity was calculated by using the formula:

$$\text{Percent total pores} = 100 \text{ percent} - \frac{\text{(bulk density)}}{\text{(particle density)}} 100$$

Clay was determined by the hydrometer method, sand by sieving, and silt by difference. Rainfall records were kept at each test site. Gravimetric measurements were made at several sites.

Crop yields were converted to standard tons of sugarcane. The juice of a standard ton of sugarcane contains 12 percent sucrose and has a 76 percent purity. Samples of sugarcane were taken from each plot and the juice extracted. Sucrose content and juice purity were determined by the cooperating plantation sugarhouses. The standard factors of the sugarcane industry were used to convert field tons to standard tons.

The earlier experiments were conducted with variety C.P. (Canal Point) 44-101 with the exception of Poplar Grove, where variety C.P. 36-105 was used. Some of the later experiments, conducted in cooperation with the Crops Research Division of ARS, were designed to study the variety x tillage treatment interactions.

RESULTS AND INTERPRETATIONS

Changes in Soil Physical Properties

Certain physical changes in the soil occurred in response to different tillage treatments. The magnitude of these changes depended on the specific soil types. Soil physical changes are described below for different soil types. However, it is apparent that one of the difficulties in interpretation of the soil physical data is the inherent variation in alluvial soils.

Fine Sandy Loam

A comparison of specific soil physical properties of fine sandy loam before and about 1 year after tillage treatments were imposed shows few residual differences. However, subsoiling and deep plowing did decrease bulk density and increase total porosity in the 6- to 9-inch soil layer. These effects were still apparent 1 year after tillage treatments had been imposed.

Silt Loam

Subsoiling and deep plowing created large changes in soil physical properties of Mhoon silt loam in the River section. Permeability rate in the 6- to 9-inch layer of soil increased fourfold, percentage of large pores increased twofold, total porosity increased 14 percent, and bulk density

Table 2.--Influence of tillage treatments on changes in physical properties in 6- to 9-inch layer of soil sampled in 1956 before tillage treatments and 1 year later

Tillage treatment	Permeability		Bulk density		Total pores		Large pores		Clay		Sand	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
	In./hr.	In./hr.	g./cc.	g./cc.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
FINE SANDY LOAM (COMMERCE AND MHOON) ALLUVIUM [1]												
Conventional	0.04	0.03	1.47	1.52	43.2	41.5	4.8	2.8	30	31	18	12
Subsoiled 14 and 18"	.14	.09	1.49	1.42	42.7	45.2	4.5	7.0	26	30	22	19
Deep plowed 18"	.06	.15	1.46	1.42	44.1	45.3	5.4	5.3	29	26	18	20
SILT LOAM (MHOON) ALLUVIUM [2]												
Conventional	0.03	0.29	1.50	1.56	42.2	43.6	4.1	5.3	39	40	10	6
Subsoiled 14 and 18"	.05	.27	1.53	1.37	41.2	47.5	4.7	9.2	39	35	11	10
Deep plowed 18"	.11	.36	1.52	1.38	41.7	47.0	4.4	8.0	38	34	16	11
SILTY CLAY LOAM (BALDWIN, MHOON, AND SHARKEY) ALLUVIUM [1]												
Conventional	--	0.01	--	1.47	--	43.3	--	3.9	--	53	--	8
Subsoiled 14 and 18"	--	.01	--	1.44	--	44.6	--	3.7	--	55	--	12
Deep plowed 18"	--	.03	--	1.41	--	44.9	--	4.7	--	52	--	7
LOESS SILT LOAM (LINTONIA, OLIVIER, AND RICHLAND) UPLANDS [2]												
Conventional	--	0.16	--	1.46	--	43.8	--	5.2	--	34	--	1
Subsoiled 14 and 18"	--	.27	--	1.38	--	47.0	--	8.2	--	33	--	2
Deep plowed 18"	--	.27	--	1.35	--	48.0	--	8.4	--	32	--	2

[1] Each value is a mean for 12 cores.
[2] Each value is a mean for 8 cores.

Table 3.--Influence of tillage treatments on changes in physical properties in 12- to 15-inch layer of soil sampled in 1956 before tillage treatments and 1 year later

Tillage treatment	Permeability		Bulk density		Total pores		Large pores		Clay		Sand	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
	In./hr.	In./hr.	g./cc.	g./cc.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
	FINE SANDY LOAM (COMMERCE AND MHOON) ALLUVIUM[1]											
Conventional	0.14	0.08	1.42	1.44	45.4	45.2	4.5	4.2	31	33	18	13
Subsoiled 14 and 18"	.13	.06	1.42	1.50	45.2	42.4	4.9	3.7	25	32	22	13
Deep plowed 18"	.02	.07	1.44	1.41	44.5	44.5	4.6	5.8	29	26	14	18
	SILT LOAM (MHOON) ALLUVIUM[2]											
Conventional	0.20	0.85	1.40	1.38	46.1	46.8	4.4	6.7	40	39	9	6
Subsoiled 14 and 18"	.38	.44	1.44	1.39	47.8	46.4	6.2	6.9	35	36	18	11
Deep plowed 18"	.36	.46	1.42	1.36	45.4	47.8	6.4	7.6	30	38	18	8
	SILTY CLAY LOAM (BALDWIN, MHOON, AND SHARKEY) ALLUVIUM[1]											
Conventional	--	0	--	1.40	--	46.2	--	2.8	--	65	--	4
Subsoiled 14 and 18"	--	0	--	1.36	--	47.6	--	2.8	--	56	--	9
Deep plowed 18"	--	0.05	--	1.39	--	42.8	--	3.5	--	56	--	7
	LOESS SILT LOAM (LINTONIA, OLIVIER, AND RICHLAND) UPLANDS[2]											
Conventional	--	0.21	--	1.42	--	45.3	--	5.9	--	33	--	2
Subsoiled 14 and 18"	--	.13	--	1.46	--	44.1	--	5.4	--	34	--	2
Deep plowed 18"	--	.10	--	1.43	--	44.9	--	5.5	--	32	--	2

---

[1] Each value is a mean for 12 cores.
[2] Each value is a mean for 8 cores.

decreased 10 percent. These changes were greater than those for any other soil. The changes were not so great in the 12- to 15-inch layer as in the 6- to 9-inch layer.

One interesting anomaly in permeability rate 1 year after conventional tillage should be noted in table 3. The highest permeability rate, 0.85 inch per hour, was measured in the 12- to 15-inch layer of soil in conventionally tilled plots. This value is the mean of measurements made on eight different cores, of which five had values ranging from 0.86 to 1.29 inches per hour. No good explanation can be given for these differences since the 12- to 15-inch soil layer in the conventional tillage plot was probably not disturbed by tillage. It does appear, however, that conventional tillage increased the permeability rate. The possible significance of this increased permeability rate will be mentioned in the section on crop response.

Silty Clay Loam

Compared to conventional tillage, no important differences existed in soil properties of silty clay loam measured 1 year after different tillage treatments were imposed. The permeability rate was extremely low, ranging from zero to 0.05 inch per hour (table 3).

Loess Silt Loam

Marked changes in physical properties of the 6- to 9-inch layer of soil samples of loess silt loam were evident one year after subsoiling and deep plowing (table 2). Compared to conventional tillage, the percentage of large pores increased 60 percent, permeability increased 70 percent, and bulk density decreased 7 percent. An examination of the permeability of the 12- to 15-inch layer of silt loam in the loess land resource area reveals a relationship similar to that found in the silt loams of the delta land resource area. Permeability in the conventional tillage plots was about twice that in the subsoiled and deep-plowed plots.

Clay (Sharkey)

No soil physical determinations were made on the clay soils because unpublished data from working the cotton area showed that no physical response was obtained.

Soil Moisture Response

The soil moisture extraction pattern was changed by the deep-tillage treatments. The magnitude of this change depended on the specific soil type. Data on a percent moisture volume basis are presented in figures 8 to 11 and monthly distribution of rainfall presented in table 4. The spot soil moisture samples were taken to 36 inches in depth.

Following are comparisons of the soil moisture response for conventional treatment, subsoiling 14 and 18 inches deep, and deep plowing 18 inches, on each of the soil types tested.

Fine Sandy Loam (Mhoon) Alluvium (LA-8)

This soil moisture extraction study was made in 1955 in the River Section on experimental site LA-8. The most significant finding pertaining to moisture extraction was that deep plowing resulted in a linear relation between moisture content and profile depth. In contrast, the conventional tillage usually resulted in a break in the curve at the 24-inch depth (fig. 8). The linear relation indicates that sugarcane root penetration was greater in deep-tilled plots than in conventionally tilled plots.

Silt Loam (Mhoon) Alluvium (LA-16)

This soil moisture extraction study was made in 1957 from April through August. The experimental site (LA-16) was located in the Gulf section where the water table is generally much closer to the surface than in other geographical sections. The monthly distribution of rainfall in this section was quite uniform in 1957 (table 4). The volumetric moisture content was

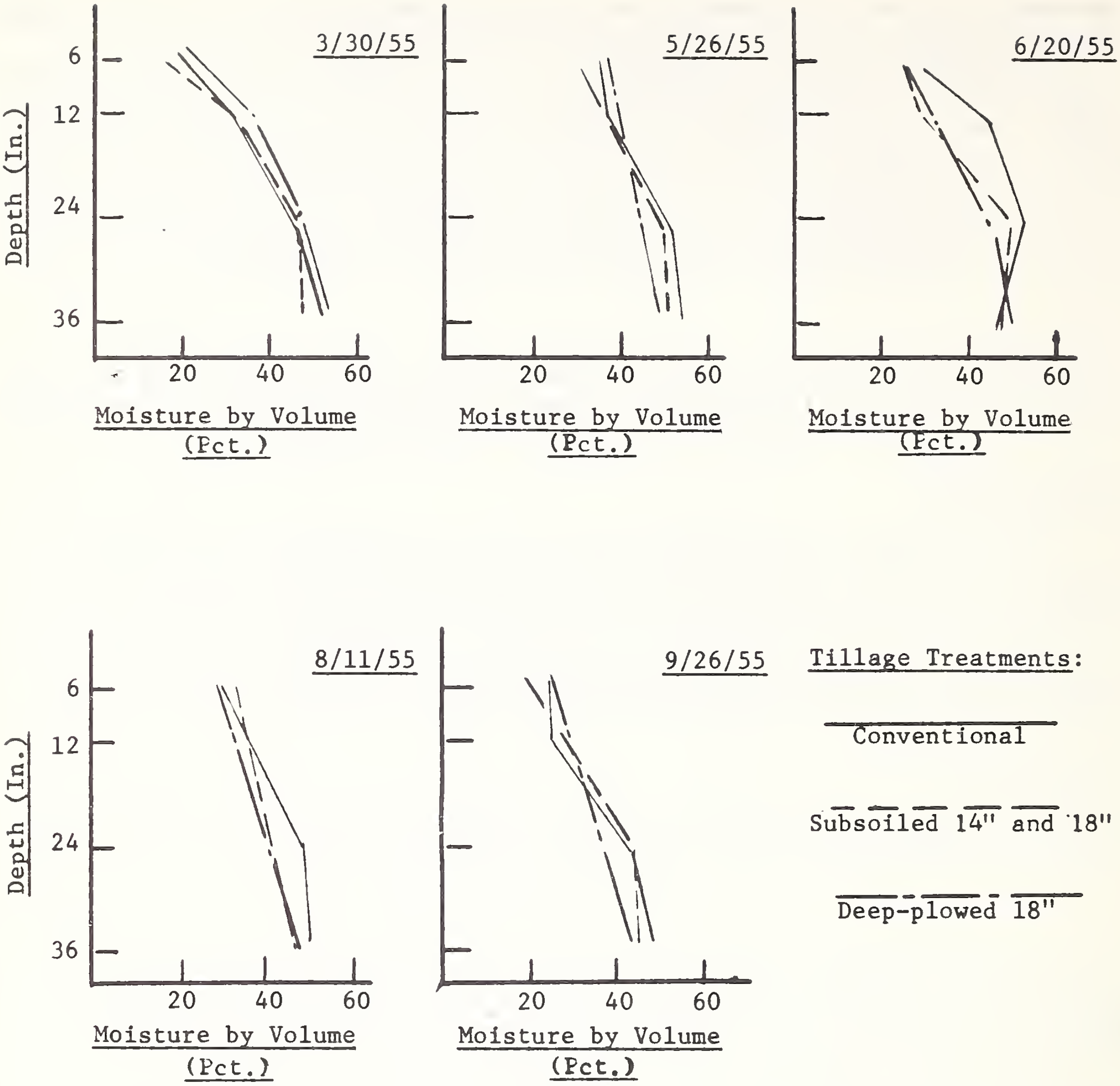

Figure 8.--Moisture content in soil profiles of fine sandy loam (Mhoon) alluvium (LA-8), as affected by tillage treatments.

greater than 40 percent at the 15-inch depth for all treatments and dates (fig. 9). More water was present in soil profiles that had been subsoiled or deep plowed than in those conventionally tilled.

Silty Clay Loam (Baldwin) Alluvium (LA-18)

In 1957 the soil moisture extraction study (experimental site LA-18) was made May 28 through October 10 (fig. 10). On May 28 the deep-plowed plots had a higher moisture content at the 3- to 15-inch depth than the conventional, with the highest moisture in the deep-plowed treatment. At the 33-inch depth the conventional plots had 7 percent more moisture than the subsoiled plots, and 12 percent more than the deep-plowed plots. In June, when the heavy rains occurred, there was little difference among any of the plots at the 33-inch depth. On July 11 a

Table 4.--Monthly distribution of rainfall in experimental sites in fine sandy loam (LA-8), silt loam (LA-16), silty clay loam (LA-18), and loess silt loam (LA-19)

Date	Rainfall distribution in--			
	Fine sandy loam (LA-8)	Silt loam (LA-16)	Silty clay loam (LA-18)	Loess silt loam (LA-19)
	In.	In.	In.	In.
1955:				
March	0.4	--	--	--
April	8.4	--	--	--
May	4.6	--	--	--
June	1.8	--	--	--
July	5.8	--	--	--
August	7.2	--	--	--
September	1.2	--	--	--
1957:				
April	--	6.4	3.6	6.9
May	--	3.1	4.6	4.6
June	--	8.4	12.3	10.8
July	--	7.6	3.4	3.4
August	--	7.0	1.8	4.2
September	--	--	8.8	--
October	--	--	9.2	--

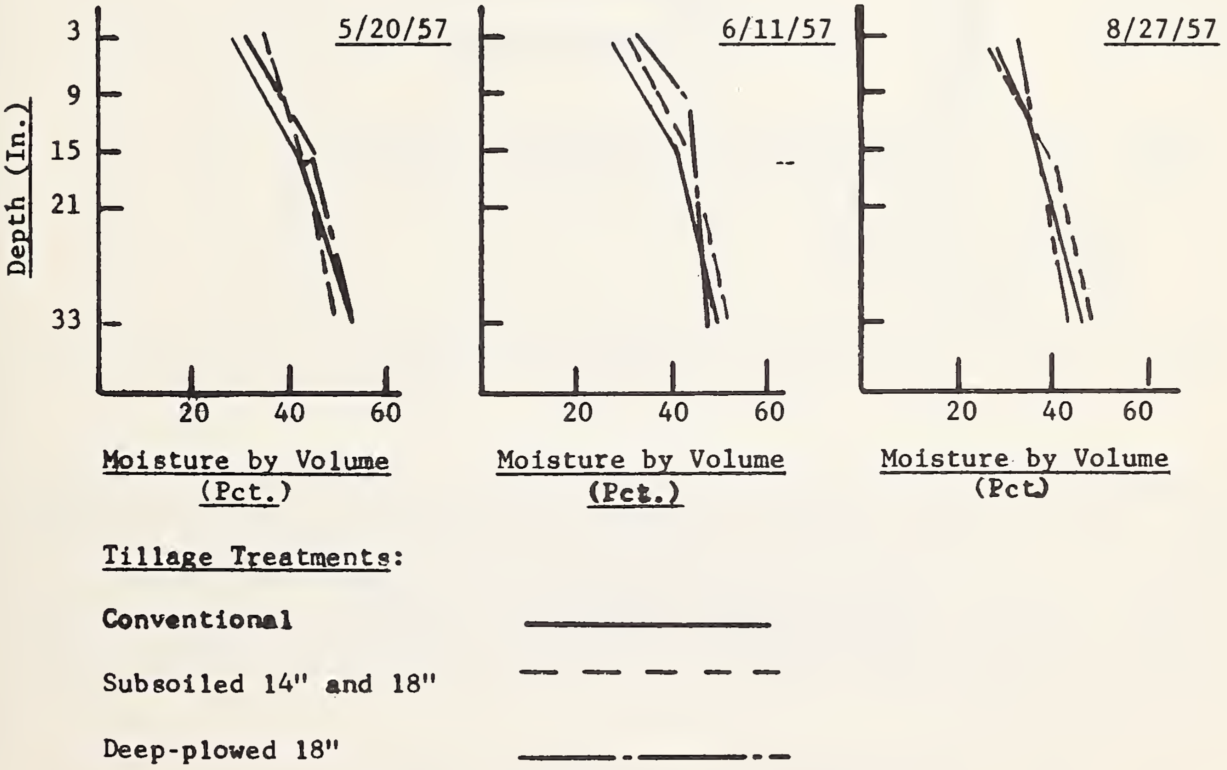

Figure 9.--Moisture content in soil profiles of silt loam (Mhoon) alluvium (LA-16), as affected by tillage treatments.

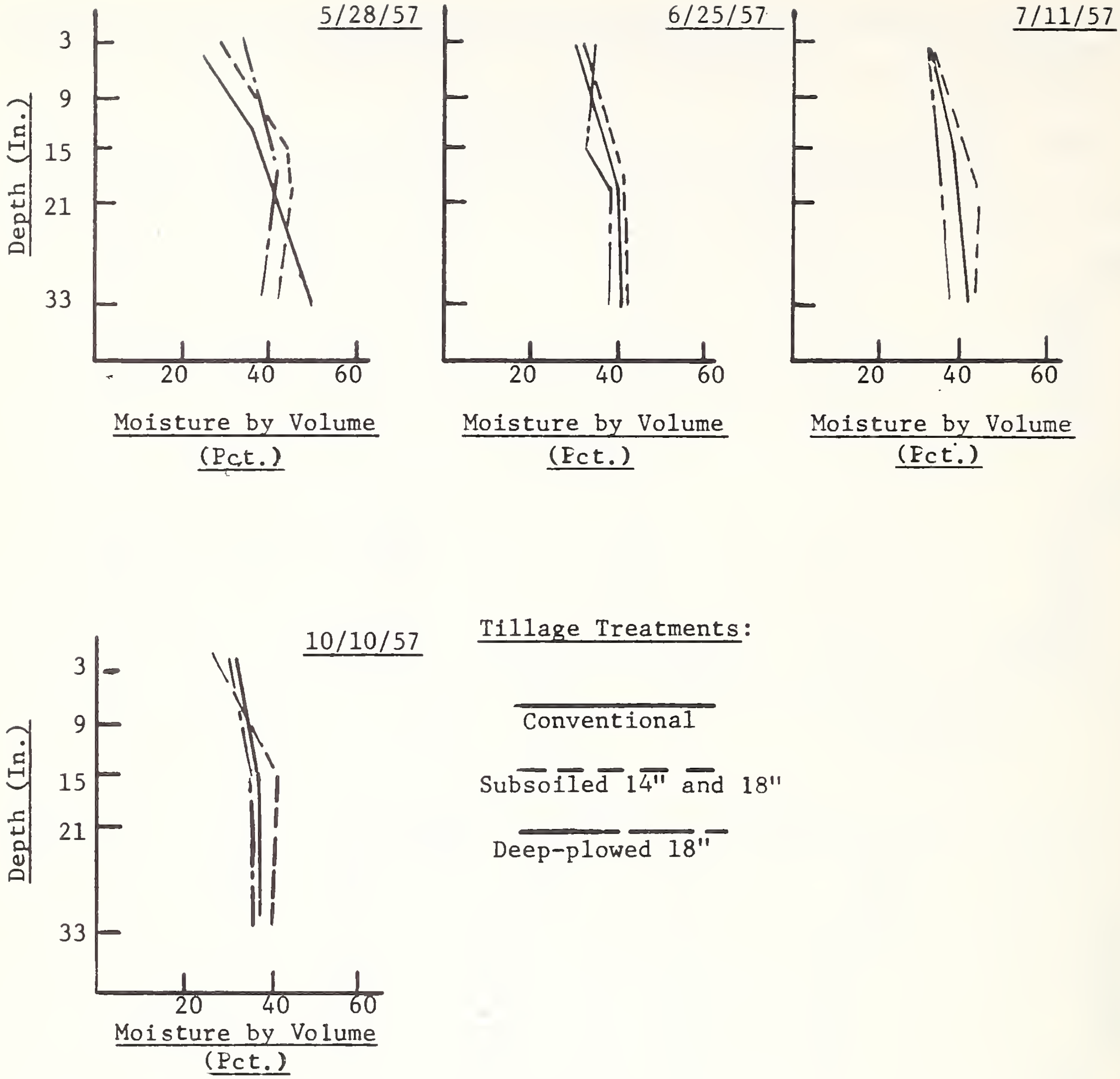

Figure 10.--Moisture content in soil profiles of silty clay loam (Baldwin) alluvium (LA-18), as affected by tillage treatments.

difference began to show at the 21- to 33-inch depth, with the subsoiled plots having 4 percent more moisture. In October, the subsoiled plots had approximately 3 percent higher moisture content at the 15- to 33-inch depth. In general, a linear relation between moisture content and profile depth appeared to exist in soil that had been deep plowed. This was observed in fine sandy soil also. The moisture extraction patterns on July 11 and October 10 show that the moisture content was consistently higher in the 9- to 33-inch depth of subsoiled plots than in other plots. This additional supply of moisture may have been related to the yield increase of 3.94 tons in 1957 in subsoiled plots (table 5).

Table 5.--Summary of total annual rainfall and increase or decrease in yields of sugarcane due to deep-tillage treatments on different soil types for different years

[Figures in parentheses indicate number of replications and the sum of test sites for the year]

Year	Total annual rainfall (in.)	Experimental site No., LA--	Yield increase or decrease (std. tons per acre) due to tillage treatments					
			Conventional	Subsoiled		Deep plowed		Scarified
				18 in.	14 and 18 in.	14 in.	18 in.	14 in.
FINE SANDY LOAM (COMMERCE AND MHOON) ALLUVIUM								
1955	51.71	8	33.2(2)	--	-0.23(2)	1.22(2)	2.16(2)	--
1956	40.19	8	33.6(2)	--	4.45(2)	3.90(2)	6.47(2)	--
1957	65.55	14, 15	29.2(7)	2.93(7)	3.90(7)	5.27(7)	3.82(7)	--
1958	60.97	8, 14, 15	28.8(9)	-.68(7)	6.47(9)	5.91(9)	4.69(9)	--
Mean	--		29.9(20)	1.12(14)	4.67**(20)	4.82**(20)	4.70**(20)	--
SILT LOAM (MHOON) ALLUVIUM								
1957	73.19	16	31.7(4)	1.26(4)	0.37(4)	1.34(4)	1.56(4)	--
1958	53.21	16, 19	39.8(8)	-2.70(8)	-4.25(8)	.13(8)	-.73(8)	--
1959	69.77	16, 19	30.4(7)	.96(7)	-1.09(7)	-.57(7)	1.12(7)	--
1961	77.87	16	39.0(4)	--	-.82(4)	--	1.02(4)	1.59(4)
1962	33.14	16	41.3(4)	--	.88(4)	1.13(4)	-.83(4)	.00(4)
Mean	--		36.3(27)	.53(19)	-1.33(27)	.30(23)	.43(27)	.79(8)
SILTY CLAY LOAM (BALDWIN, MHOON, AND SHARKEY) ALLUVIUM								
1955	49.84	8, 10	30.4(4)	--	2.98(4)	--	2.13(4)	1.97(4)
1956	50.41	8, 10	35.2(4)	--	-1.53(4)	--	2.76(4)	-2.52(4)
1957	62.25	18	17.1(4)	2.52(4)	3.94(4)	2.40(4)	4.43(4)	--
1958	59.48	8	29.4(2)	--	-1.07(2)	--	5.64(2)	--
1959	68.23	18	30.7(4)	.32(4)	.76(4)	2.50(4)	1.24(4)	--
1961	69.57	18	29.0(4)	--	1.64(4)	3.92(4)	4.81(4)	2.49(4)
1962	40.20	18	22.2(4)	--	3.29(4)	6.41(4)	5.21(4)	1.81(4)
Mean	--		27.6(26)	--	1.19(22)	3.81*(16)	3.32**(26)	--
CLAY (IBERIA AND SHARKEY) ALLUVIUM								
1955	63.45	9, 11	27.4(6)	--	0.47(6)	--	1.63(6)	0.65(6)
1956	53.13	9, 11	29.5(6)	--	1.02(6)	--	.06(6)	.44(6)
Mean	--		28.5(12)	--	.74(12)	--	.81(12)	.57(12)
LOESS SILT LOAM (LINTONIA, OLIVIER, AND RICHLANDS) UPLANDS								
1957	74.20	17	24.4(4)	2.86(4)	0.93(4)	1.08(4)	0.99(4)	--
1958	52.83	17	18.4(4)	-4.24(4)	-1.45(4)	.42(4)	.01(4)	--
Mean	--		21.4(8)	-.69(8)	-.26(8)	.75(8)	.50(8)	--

** Significant at 1-percent level.

* Significant at 5-percent level.

Loess Silt Loam (Lintonia, Olivier, Richland) Uplands (LA-17)

In 1957, the soil moisture extraction study (experimental site LA-17) was made May 21 through July 11 (fig. 11). The soil moisture content in subsoiled and deep-plowed soils was consistently lower, about 4 percent, than in conventionally tilled plots. This condition appears to be related to changes in physical properties as a result of tillage. Bulk density was decreased and permeability and percentage of large pores were increased by subsoiling and deep plowing (table 2).

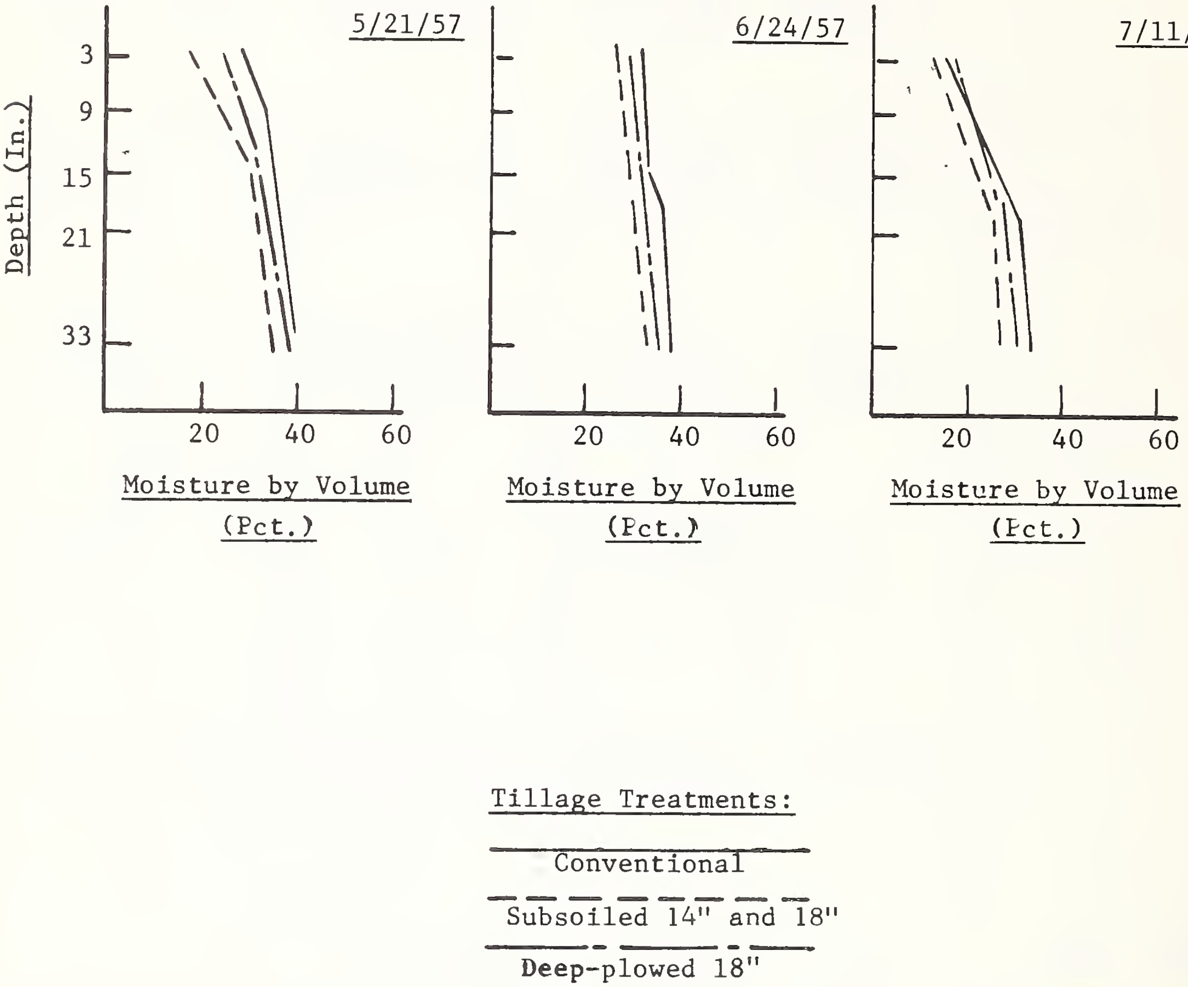

Figure 11.--Moisture content in soil profiles of loess silt loam (Lintonia, Olivier, and Richland) uplands, as affected by tillage treatments.

Crop Response

Yields of sugarcane obtained by conventional tillage and the comparable changes in yields due to different deep-tillage treatments are presented in table 5. The nature and magnitude of the influence of deep tillage depended on the soil type and amount and distribution of rainfall in the various geographical areas.

Sugarcane production per acre in the southern Mississippi River alluvial soils under conventional tillage averaged about 30 tons on fine sandy loams, 36 tons on silt loams, and 28 tons on silty clay and clay soils. The silt loams of the loess land resource area had the lowest production, 21 tons.

The greatest yield increases were obtained by either subsoiling or deep plowing on the fine sandy loams and silty clay loams. Variations in response existed between years for each of the soil types as discussed below.

Fine Sandy Loam

Deep tillage had a significant influence on sugarcane production in the three River section tests on fine sandy loam soils. One test was conducted in 1955 and 1956 and the other two in 1957 and 1958. The crop response to deep tillage in 1955 was small, probably because adequate rainfall occurred in August.

Table 5 shows that by subsoiling 14 and 18 inches deep a mean increase of 4.67 standard tons per acre occurred in sugarcane production over the conventional plots; by deep plowing 14 inches, 4.82; and by deep plowing 18 inches, 4.70. These increases, for 20 replications, were significant at the 1-percent level.

Silt Loam

Deep tillage did not have a significant influence on sugarcane production on the silt loam soils. One test (LA-19) was located in the River section and the other (LA-16) in the Gulf section. The two tests were conducted from 1957 through 1959 and the Gulf section was reworked and carried through 1961 and 1962.

This lack of crop response cannot be explained easily or with certainty, particularly since silt loam soils responded in the cotton area of Louisiana. A soil physical response was obtained in the sugarcane area, including a reduction in bulk density and increases in permeability, large pores, and total porosity. However, the soil moisture extraction pattern did not vary significantly among treatments.

Another possible explanation for the lack of crop response was that these test areas in the Gulf section had high-producing soils. Conventional tillage plots yielded 36 standard tons of cane per acre, whereas conventional plots on other soil types in this investigation yielded from 21 to 30 tons per acre. The fact that the test in the Gulf section is in a high rainfall belt and has a higher water table may also be pertinent.

Silty Clay Loams

Deep tillage had a significant influence on sugarcane production in the three tests on silty clay loam soils. One test was located in the River section, one in the Gulf section, and one in the Western section. The River section test was conducted in 1955, 1956, and 1958; the Gulf section in 1955 and 1956; and the Western section in 1957, 1959, 1961, and 1962.

The River section responded to subsoiling 14 and 18 inches deep in 1955, with an increase of 4.37 standard tons of sugarcane per acre. Deep plowing 18 inches gave a mean increase of 3.51 standard tons for the 3-year test.

The Gulf section had an increase in sugarcane for all deep tillage treatments in 1955. Subsoiling 14 and 18 inches deep had an increase of 1.48 standard tons per acre; scarifying, 2.03; and deep plowing, 3.78. In the second year of the tests, the deep tillage did not increase yields; however, the conventional plots produced a high average of 35.75 standard tons per acre.

The Western section responded to subsoiling 14 inches deep in 1957. Significant increases in yields were obtained by subsoiling 14 and 18 inches deep in 1957, 1961, and 1962, with increases of 3.94, 1.64, and 3.29 standard tons of sugarcane per acre, respectively. The most consistent increase during the 4 years was obtained by deep plowing at both the 14- and 18-inch depths, with a mean of 3.81 standard tons per acre for the 14-inch depth and a mean of 3.92 standard tons per acre for the 18-inch depth. The increase in crop production due to deep tillage of silty clay loams is attributed to a better moisture regime in periods of below-normal rainfall. Sugarcane production was increased 1.19, 3.81, and 3.32 tons per acre for subsoiling at two depths, deep plowing 14 inches, and deep plowing 18 inches, respectively, compared to conventional tillage (table 5).

Clays

No differences in sugarcane production occurred on clay soils due to the tillage variables.

Loess Silt Loams

There were practically no increases in production on the upland silt loam soils in this test, in 1957 and 1958. The results are similar to those obtained in another study in the cotton-area of Louisiana.

Variety x Tillage Interactions

The varieties C.P. 44-101 and C.P. 36-105 were both harvested as plant cane at Georgia (LA-16) and Oaklawn (LA-17) plantations in 1957; as first stubble cane at Georgia in 1958; and, as second stubble cane at both plantations in 1959. Data for these five crops are given in table 6 and show the comparative effects of the tillage treatments on the two varieties of sugarcane. These data were used to calculate the variety x tillage treatment interaction values by the procedure described by Arceneaux and Hebert.[4] The variety C.P. 44-101 responded best to deep plowing, and the variety C.P. 36-105 responded best to subsoiling. With C.P. 44-101, the deep plowing

---

[4] Arceneaux, George, and Hebert, L. P. A statistical analysis of varietal yields of sugarcane obtained over a period of years. Jour. Amer. Soc. Agron. 35: 148-160. 1943.

Table 6.--Comparative effects of tillage treatments on yields of two sugarcane varieties (five crops) planted at Georgia (LA-16) and Oaklawn (LA-18) plantations in the fall of 1956

[Values are totals for five crops]

PRODUCTION DATA

Variety [1]	Yield (standard tons per acre)					
	Conventional	Subsoiled		Deep-plowed		Mean
		18 in.	14 or 18 in.	14 in.	18 in.	
C.P. 44-101	144.57	143.45	141.49	156.97	154.72	148.24
C.P. 36-105	141.37	152.99	152.92	145.61	150.47	148.67
INDIVIDUAL VALUES FOR VARIETY X TILLAGE TREATMENT INTERACTIONS [2]						
C.P. 44-101	+1.82	+5.90	+2.34	-4.55	-5.50	
C.P. 36-105	-1.81	-5.89	-2.34	+ 4.56	+5.50	

ANALYSIS OF VARIANCE

Item	Standard deviation	Value for P	
		0.05	0.01
Single values	3.3	6.75	0.06
Difference between values for the same variety with different treatments	5.27	10.69	14.33

[1] C.P. = Canal Point.

[2] From summation given in table A, for example, value for C.P. 44-101 with conventional treatment =144.57 + 148.46 - 148.24 - 142.97 = 1.82.

produced significantly (0.05) more cane than the subsoiling treatment. In contrast, C.P. 36-105 produced significantly (0.05) more cane with the subsoiling treatment at two levels than with the deep plowing at 14 inches, and the subsoiling at 18 inches was almost significantly better than the deep-plowing at 14 inches. In another experiment at Georgia and Oaklawn plantations, the same yield pattern was shown for C.P. 44-101 variety, with the deep plowing to a depth of 14 inches consistently superior to the subsoiling at two depths. The latter experiment gave an average increase of 500 pounds of commercially recoverable sugar per acre for deep plowing compared to subsoiling.

SUMMARY AND CONCLUSIONS

The deep-tillage investigations on the southern Mississippi Valley Alluvium and Silty Uplands of the sugarcane area of Louisiana indicate that the fine sandy loam and silty clay loam soil groups responded in terms of sugarcane yields to deep tillage. The silt loam alluvium, clay alluvium, and loess silt loam uplands did not respond. The greater responses were obtained in years of poor rainfall distribution during the growing season. Geographically, the River and Western sections responded consistently, but the Gulf section responded only 1 year.

The average crop response on fine sandy loam alluvium from 1955 through 1958 to subsoiling 14 and 18 inches deep was an increase of 4.67 standard tons per acre over the yield from conventional tillage; the increase due to deep plowing 14 inches was 4.82 standard tons; and that due to deep plowing 18 inches, 4.70 standard tons. These increases were significant at the 1-percent level. Moisture extraction patterns indicated that plant roots extracted water to a greater depth in the deep-tilled soil profile.

Although no significant crop response was obtained in the tests in 1957-59 and 1961-62 on silt loam alluvium, there was a significant soil physical response. The explanation for the lack of crop response is not known. One influential factor may have been the relatively high yield of the conventional plots.

The average crop response of tests in 1955-59 and 1961-62 on silty clay loam alluvium for subsoiling 14 and 18 inches deep was 1.19 standard tons per acre; plowing 14 inches, 3.81; and plowing 18 inches, 3.32. The crop response obtained by deep plowing 14 inches deep on 16 replications was significant at the 5-percent level, and that by deep plowing 18 inches deep on 26 replications was significant at the 1-percent level. The tillage treatments caused little change in the soil physical characteristics.

No crop responses were obtained from deep tillage tests in 1955-56 on clay alluvium or in tests in 1957-58 on loess silt loam uplands, although the soil properties of the silt loam uplands did change.

Limited soil moisture studies indicate that during periods of sparse rainfall the deep-tilled plots contained more moisture at the 0- to 12-inch depth than conventional plots. These plots also showed a greater moisture extraction at the 24- to 36-inch depth, which indicates a deeper rooted crop.

In a sugarcane x tillage interaction study, the variety C.P. 44-101 produced a significantly higher yield of 3.10 standard tons per acre from the 14-inch deep-plowed treatment, as compared with the 14- or 18-inch subsoiled treatment. The reverse was true with the variety C.P. 36-105, which produced 1.46 more standard tons per acre from the subsoiled treatment. The reverse was true with the variety C.P. 36-105, which produced 1.46 more standard tons per acre from the subsoiled treatment. In other studies, the variety C.P. 44-101 showed the same pattern of tillage treatment response.

Deep tillage should pay dividends on fine sandy loam and silty clay loam in the sugarcane area, especially in years of poor rainfall distribution. The mean yield increase over the conventional treatment for the deep-plowing 18 inches was 4.70 standard tons per acre for fine sandy loam and 3.32 for silty clay loam.

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service
Beltsville, Maryland 20705

Official Business

Postage and Fees Paid
U.S. Department of Agriculture